A Consideration of the Vascular Mechanism of the Nasal Mucous Membrane and its Relations to Certain Pathological Processes.

BY

JONATHAN WRIGHT, M.D.,
OF BROOKLYN, L. I.

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A CONSIDERATION OF THE VASCULAR MECHANISM OF THE NASAL MUCOUS MEMBRANE AND ITS RELATIONS TO CERTAIN PATHOLOGICAL PROCESSES.

By Jonathan Wright, M.D.,
of Brooklyn, L. I.

The blood-supply to the turbinated bodies possesses an interest for the rhinologist due largely to the bearing its proper appreciation has upon his comprehension of the pathological lesions and clinical phenomena in the various arbitrary divisions of rhinitis. Whatever may be the exact anatomical inter-relation of arteries, capillaries, veins, and venous sinuses, it is evident that they cannot overcome the elastic resistance to their dilatation without some arrangement for checking the venous return. There are no specially adapted muscles to compress a few veins, as in the penis; there is no tunica albuginea to exert compression.

In studying the subject it will be necessary to describe shortly the vascular anatomy of the turbinated bodies. Zuckerkandl has rendered this task a comparatively easy one.

The larger arterioles well supplied with muscular coats lie in the deepest layers of the mucous membrane close to the bone. They give off branches which supply, by a network of capillaries, the periosteum, the glands, and the epithelial layer of the mucous membrane. These capillaries are collected into the veins, which dilate into venous sinuses, the larger lacunæ of which are the deeper, the superficial lacunæ or "cortical network" communicating with them. These lacunæ again empty into the veins which accompany the primary arterioles into the periosteal layer.

Zuckerkandl says he has never seen the arteries emptying directly into the venous sinuses. The same was said for a long time of the corpus cavernosum of the penis, but they were finally conclusively shown to do so, and I am not convinced that this does not occasionally take place in the erectile bodies of the nasal mucous membrane, though I have thus far been unable to trace the connection between the two.

The capillaries, usually at least, do not empty directly into the venous sinuses nor into the radical veins accompanying the arteries. They are usually seen collected first into veins. The smaller veins of the periosteal layer empty directly into the radical veins accompanying the arterioles.

It is a matter of the greatest difficulty in this country, even in New York, to obtain adult heads fresh enough post mortem, which may be opened and the nasal mucous membrane removed for microscopic study. Infants, stillborn or dying shortly after birth, may be easily obtained, but the erectile tissue (the venous sinuses) does not develop fully until near the time of puberty. It is possible in the "dead-house" to saw off the inferior turbinated bones through the nostrils in adult subjects, but in this climate the microscope will usually reveal a pathological condition of the mucous membrane. In animals the vascular arrangement differs in many respects from that of man. The sheep has no erectile tissue. The calf has cavernous sinuses on the posterior border of the septum which more nearly resemble the corpus cavernosum of the penis in having a thick external tunic and no muscle-fibres in the walls of the sinuses.

Nevertheless, by comparing all these different conditions the probable mechanism of the blood-supply in the highly evolved nasal mucous membrane of man becomes pretty evident. The radical arteries and veins pass through various bony canals into the nose, as the large spheno-palatine foramen and smaller foramina in the ethmoid. The artery will evidently compress, when dilated, its accompanying vein against the bony walls, thus letting in more blood and limiting the outflow. Contraction of the artery acts in the inverse sense. This arrangement has been described for the blood-supply of the marrow of the long bones.

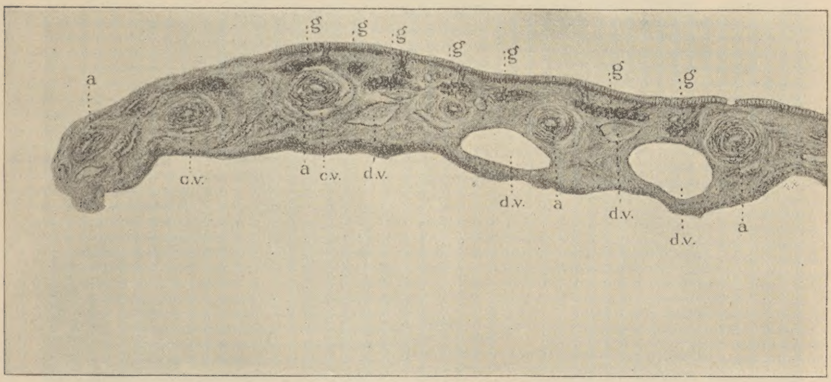
There is a similar mechanism, as the arterial branches with their veins lie in the deep or periosteal layer of the mucous membrane.

Fig. 1 shows very clearly how this occurs in the sheep. You will observe that many of the large veins lie between the very muscular arteries and the firm periosteum at the level of this particular section. Of the thirty or forty sections examined, this arrangement was evident in so many pairs that it is fair to presume that at some one or more points each radical artery and vein stand in such a mutual relation that an increase in the diameter of the artery must result in an encroachment upon the lumen of the vein without entirely closing it. While this drawing is from the mucous membrane of the sheep, the same arrangement, by careful study, will frequently be found in that of man; but, owing to the very much more complex and irregular course of the vessels, it does not present such a striking and convincing illustration.

There is such a complete anastomosis of the superficial veins with one another, with those of the skin at the edge of the nostrils, with the veins of the dura mater and of the orbit, that this obstruction to the venous return probably exerts its dilating tendency only or chiefly upon the *deep* network of the erectile bodies. It does act, however, upon them as the supply and escape valve to the cavernous sinuses, and stands in

the place of the muscles which compress the radical veins of the penis. As Zuckerkandl has said, after a study of the microscopic structure of the nasal mucous membrane, one is impressed with the large amount of muscle-fibre with which its various elements are supplied. The walls of the larger arterioles are very thick, while some vessels with lumina no larger than those of the larger capillaries are supplied with well-developed circular muscle-fibres. Still more unusual is the amount of muscular tissue in the walls of the veins. In Fig. 2, from the same series of sections as Fig. 1, you will see a high-power drawing of a radical vein which happens to be cut obliquely so as to show perfectly its circular fibres. Comparing them with those of the adjacent artery, which is cut more squarely across, you will observe that they are very much more scanty, but, nevertheless, sufficiently plentiful to exert considerable influence upon the lumen of the vessel. As you look at this drawing the question will arise whether the contraction of the muscle-fibres of the vein is synchronous with those of the artery. You will observe that the artery, even in its contracted state, encroaches on the walls of the vein, which is evidently dilated, as are many of the veins in Fig. 1.

Fig 1.



Nasal mucous membrane of sheep. $\times$ 10.
a. Artery. g. Gland. d.v. Dilated vein. c.v. Closed vein.

This is a point which, while very interesting, is not as yet clearly explained by the physiologist. Even if they do contract and dilate synchronically, the pressure of the dilated artery would sufficiently narrow the lumen of the relaxed vein. In contraction of the artery, on the other hand, the venous fibres would tend to prevent the excessive dragging apart of the venous walls and the over-engorgement of the vein. In man we have these same muscular veins receiving the blood from the venous sinuses, the walls of which are themselves plentifully

supplied with muscle-fibres. The areolar tissue in the neighborhood of veins and venous sinuses is also in man more or less plentifully supplied with muscle-fibres. This richness in muscle-fibre is the arrangement

Fig. 2.

Deep layer of nasal mucous membrane of sheep. × 300.

which supplies the place of the tunica albuginea of the penis in driving the blood out of the tissues when the gateways of the radical veins are opened.

Before leaving this part of the subject I cannot refrain from wandering a little into the domain of pathology. The venous sinuses, as we have seen, depend largely for their expulsive power upon their muscular walls. Now we find in chronic rhinitis the walls of these vascular spaces very much thickened by the overgrowth of non-elastic fibrous tissue of a low grade of development. This must manifestly interfere with efficient contraction of the muscle-fibres. In the hypertrophy of these bodies we have, therefore, not only a dilatation of the lacunæ but a paresis of their walls.

FIG. 3.

Nasal mucous membrane from septum of infant. $\times$ 50.
a. Periosteal layer. v. Radicle vein. g. Gland.

Atrophy evidently has ordinarily, as its antecedent, the gradual elimination of the muscular element and the encroachment upon the vascular spaces by this fibrous hyperplasia, which itself finally becomes to some extent absorbed, leaving as a thin covering to the shrunken turbinated bones a membrane deprived of its two essential elements, the glands and the venous sinuses.

Usually, however, this process is arrested before it reaches these ex-

treme limits. Is it not reasonable to conjecture that we may find in this an explanation of the cause of atrophic rhinitis apparently beginning in so many cases about the time of puberty? This fibrosis, beginning in childhood as the result of inflammation of a low grade, must tend to prevent the development, at or near puberty, of the venous sinuses. For it is probable that, normally, this ectasia of the bloodvessels, resulting in the formation of the nasal erectile tissue, is accomplished by engorgement due to the excitability of the sexual apparatus at that time. This does not explain all the phenomena of this puzzling nasal affection, but it gives us a hint that may be amplified into more satisfactory knowledge by the study of the life-history of the glands of the nasal mucous membrane from infancy to old age. By the use of the cautery in the hypertrophy of the erectile bodies we destroy some of the vascular spaces. We do not restore the efficiency of the muscular apparatus; on the contrary, by inducing the formation of the scar we favor the tendency to fibrosis. This is evidently the reason we occasionally see marked atrophy of the mucous membrane after cauterization and other intranasal operations.

To return to normal histology: There is still another element which is apparently important in the mechanism of the blood-supply. In Fig. 3, a drawing taken from a section of an infant's nasal mucous membrane, you observe veins compressed between the parallel fibres of the periosteal layer and the elastic fibres and glands external to it. It becomes evident here, as in the case of the radical artery and vein, that engorgement of the superficial tissues supplied by dilated arterial twigs will bring an increased pressure to bear against the vein and obstruct the outflow of blood. Where this arrangement is most marked, as it is in many places on the septum, we miss the abundant muscular element in the walls of the veins. A certain amount of elastic pressure is here always present, but it is increased by the results of arterial dilatation.[1]

In the distribution of the capillaries to the surface and to the glands, the endothelial wall of the capillary is in close apposition to the epithelium of the surface and of the glands. Free nuclei may frequently be seen passing through the epithelial layer. This is especially noteworthy in the so-called olfactory region. The nuclei having no power of locomotion when deprived of the cell-body, but being simply recognizable cell-detritus, we must suppose that they are carried by the exudation of the watery part of the blood.

We may, therefore, get a transudation of serum to the surface directly from the vessels, especially in the olfactory regions, without necessarily the intervention of the glands.

[1] It is singular that by far the greater number of growths on the septum are so-called angeiomata. They probably have their origin in chronic rhinitis, which has resulted in a dilatation of the bloodvessels.

This brings us to another point. Zuckerkandl has lately described a special network of small veins so surrounding the mouths of the glands that their engorgement would necessarily close the glandular conduits.

Now these two points make a certain clinical phenomenon clear to us. The first stage of a coryza, after the somewhat problematical one of vascular contraction, is that of vascular engorgement of the erectile bodies leading to nasal occlusion. Now, with the bloodvessels all full, and with the stimulation of the glands, we should expect the secretion of mucus to be discharged almost coincidently with the congestion. As a matter of fact, we all know that for the first few hours even watery secretion is scanty, and for the first few days the discharge consists very largely of nearly clear serum. It only begins to thicken with mucus when the vascular tension relaxes. Evidently, then, the congestion of these veins encircling the glandular outlets must close the latter and prevent the escape of their contents. The watery secretion of the first stage we could account for by transudation directly from the bloodvessels through the areolar tissue and the surface epithelium.

The contraction of the smooth muscle-fibres and of the elastic fibres of the stroma contributes to the collapse of the venous sinuses, the gateways of the radical veins being opened by the contraction of the encroaching arterioles. An expression of the glandular contents also follows, subsidence of the engorgement of the superficial veins having opened the mouths of the glands.